FY 03
UNITES (UNcertainties and Interdisciplinary Transfers Through the End-to-end System)

Louis R. Bartek
Department of Geological Sciences, CB# 3315 Mitchell Hall
University of North Carolina at Chapel Hill
Chapel Hill, North Carolina 27599-3315
phone: (919) 962-0687 fax: (919) 966-4519 email: bartek@email.unc.edu

ONR Grant Number: N00014-01-1-0918

LONG-TERM GOALS

Our research group is collecting and analyzing various levels of high-resolution seismic data and cores, for ground-truthing seismic facies, on continental margins with a spectrum of depositional boundary conditions. The long-term goal of this work is develop stochastic models of variation of geotechnical and seismic property distribution on margins subjected to a spectrum of depositional regimes. The product of this research is are models of continental margins that show the probability of encountering a specific lateral distribution of geologic conditions as well as the probability that certain geologic/acoustic units will be lie beneath the seafloor and the various geologic units that lie at or near the seafloor. Essentially the product will be a measure of the level of 3-dimensional geologic variability that exists on continental margins subjected to various environmental conditions. This measure of variability is essentially the level of uncertainty that exists in our knowledge of geology of the continental margin environment. The importance of producing these stochastic models is that it provides a means of making predictions (with assignment of statistical risk) of the variation of geotechnical and seismic properties in areas where the only data that may exist for that margin at the time that a prediction is needed is information on physical oceanography or other gross descriptions of depositional conditions on the margin. We are also assessing the quantity of data that are required to recognize the nature of the variability of the geology of the margin. We call this Minimum Data Density Analysis (MINDDA) and the product of it is essentially a measure of uncertainty that is associated with making operational decisions with a specific quantity of geologic data in the operation area.

OBJECTIVES

- In years 1 and 2 of the project I will participate in the UNITES team meetings and providing assistance to them with understanding how the geologic heterogeneity impacts the acoustic measurements made in 2001 in the East China Sea (ECS) and South China Sea (SCS).
- In years 3 and 4 of the project, the level of the interaction will increase significantly when the acousticians have analyzed their data and we can then get involved in a much more extensive analysis of the interrelationships between sub-bottom geology and acoustic propagation and loss.
- Using funds from my ASIAEX grants we will quantify the nature of horizontal and vertical seismic facies heterogeneity within a sequence stratigraphic context, and develop stochastic models of seismic facies heterogeneity produced under depositional conditions associated with the ECS and then pass this information on to UNITES team members. We received support from 2 programs at ONR to

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2003**	2. REPORT TYPE	3. DATES COVERED **00-00-2003 to 00-00-2003**

4. TITLE AND SUBTITLE **UNITES (UNcertainties and Interdisciplinary Transfers Through the End-to-end System)**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of North Carolina at Chapel Hill,,Department of Geological Sciences, CB# 3315 Mitchell Hall,Chapel Hill,,NC,27599**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

collect (March and April of 2003) and analyze data at the SCS ASIAEX site and we will provide similar information to UNITES team members on this system as well.

- Use funds from my ASIAEX grant to determine the minimum data required (MINDDA) to predict the distribution of seismic attributes on margins with various depositional boundary conditions (ECS and SCS) by conducting sensitivity tests on survey spacing and associated changes in the distribution of mapped parameters.

APPROACH

Variability in the bottom and sub-bottom (0-100 meters) environment constitutes the uncertainty associated with bottom geology. Although there have been numerous studies conducted in the sub-surface on the distribution of attributes (attenuation, reflectivity, velocity, density and proxies thereof) and on exposed analogs of the sub-surface environments on land, few have quantified the nature of the vertical and lateral variability in attribute distribution. Carolina Stratigraphic Imaging Laboratory (CSIL) has been attempting to fill this gap by conducting investigations on the nature of the continental margin geologic architecture that evolves in response to change in sea level, variation in sediment supply and hydrodynamic regime on the margin. The initial effort has been focused upon locales that can be termed "extreme end-members". The end-members are in the northeast Gulf of Mexico (GOM) and the East China (ECS) and Yellow Seas (YS). The GOM locale is a low energy (micro-tidal and 1 large storm per 6 year interval) low sediment supply (Mobile Bay of Alabama, receives only 142.4 tons of sediment/year/square mile of drainage area and little of this reaches the shelf) system. The ECS and YS locales are high energy (meso-to macro-tidal and 20 to 25 large storms per year) and extremely high sediment supply. The Huanghe (Yellow River) and Changjiang (Yangtze River) Rivers respectively discharge 1.1 and 0.5 billion metric tons of sediment per year into the YS and ECS respectively. In terms of sediment discharge, these are two of the top 4 rivers in the world. To put things in perspective the Changjiang's sediment load is twice that of the Mississippi River, which is far larger than the small rivers that discharge into the northeast GOM.

The hypothesis guiding this research is that the large difference in environmental boundary conditions between the end members should produce a corresponding and predictable differences in the distribution of attributes on these margins. We will continue to identify the nature of the statistically significant trends in the lateral and vertical distribution of attributes that are associated with the variation of environmental boundary conditions in our ECS, YS, and GOM data that is associated with our other research funding. We will be able to use these associations to develop stochastic models of the spatial variability in the distribution of attributes associated with various sets of environmental conditions. We will use output of these analyses along with ongoing analyses of ECS and SCS ASIAEX data to improve our understanding of the uncertainty that is associated with the bottom geology.

Our approach to characterizing the continental margin architecture and developing the stochastic models of spatial variation in attributes involves application of sequence stratigraphic analysis of seismic data (with nested frequencies) and cores. This is followed by facies analysis of these data. The output of these analyses are subjected to Q-mode factor analysis and ANOVA to identify the statistically significant lateral distribution of attributes and to use of binomial Markov analysis to identify the non-random vertical successions in attributes within the spatial groups identified on the margin with the Q-mode factor analyses. Once these lateral and vertical attribute distributions are identified analyses are conducted to identify the minimum amount of data (MINDDA) that are required to recognize the nature of the geologic system and to successfully predict attribute distribution associated with a given system.

MINDDA involves under-sampling a data set in a mode where the interval between samples increases in an expanding geometric progression. Each under-sampled data set is then mapped and correlation between the under-sampled map and the map with the next level of sample density is measured along with variation from one map to the next in terms of shape and orientation of structures on the maps. As the density of data that is required to characterize and recognize the system is approached, the differences between the maps progressively decreases to the point that a plot of data density versus variation in correlation coefficient shows very little change and is essentially flat. The region where the curve of diminishing returns changes from large differences in correlation coefficient to small differences in correlation coefficient defines the point of at which one has acquired enough data to recognize and characterize the nature of variation of bottom geology associated with a particular set of environmental conditions. We will continue this research and integrate it with the ASIAEX research and then interact with the effort by the UNITES team to identify how uncertainty in the environment propagates through the acoustic modeling and signal processing. Our role here is to provide geological expertise as members of the UNITES team grapple with the acoustics and oceanography of the ECS ASIAEX site and later the SCS ASIAEX site. UNC personnel are dealing with these issues in the end-member systems of the ECS, YS, and NE GOM. At the ASIAEX sites we collected seismic reflection and chirp sonar data sets that have a sample density that is far greater than our older surveys in the area and we will therefore test the impact of the sample density upon our understanding spatial distribution of attributes in the ECS and SCS. The ECS ASIAEX site is also located in an area that is south of the main depositional center in the ECS, so analyses of these data are expected to reveal different spatial distributions of attributes and a different density of data required to successfully predict attribute distribution associated with this set of environmental boundary conditions.

WORK COMPLETED

Our funding is to provide resources so that we can travel and attend Uncertainty group and program meetings, to provide advise on geological matters and to provide our team with geological data for their modeling efforts and attempts to constrain uncertainty. This year Bartek participated in the Uncertainty Program workshop in Providence, Rhode Island in June and exchanged a number of telephone calls and e-mail messages with team members addressing geologic questions. CSIL also provided team members with data files containing X,Y,Z data on latitude, longitude and depth, in two-way-travel time, to various sub-bottom horizons and thicknesses of sub-bottom units.

RESULTS

We are in year 2 of the project so our role has been primarily to provide advise, participate in meetings, and provide geological data from the ECS ASIAEX site. We are currently addressing the geologic uncertainty issue following the plans discussed in the APPROACH section above.

IMPACT/APPLICATIONS

The scientific impact of this work is that it quantifies relationships between depositional boundary conditions and near-surface seismic/geotechnical properties distribution on continental margins. This therefore leads to more reliable estimates of these properties in areas where it is either difficult to acquire such data, or it is necessary to design a survey that will quickly provide needed insight, with a given level of risk of a bad prediction. It also leads to more successful design of transmission loss surveys and acoustics experiments on the role of bottom interaction on sound propagation in continental shelf environments. This obviously has impact in areas such as oil and gas exploration and

production, environmental waste containment, and of course defense related issues on continental margins.

TRANSITIONS

UNC provided OASIS (Phil Abbot) with data files and maps containing information on variation in Bottom Geology from the ECS ASIAEX site so that he has data on the scale of statistically significant heterogeneity in lateral and vertical geological attributes on the margin. UNC will also be providing Ching-Sang Chui at the Naval Postgraduate School (NPS) and personnel (Jim Lynch) from the Woods Hole Oceanographic Institution (WHOI) with information on the scale of statistically significant heterogeneity in lateral and vertical geological attributes at the SCS ASIAEX site. The acousticians will provide feedback on how the geology is impacting their measurements and models of sound propagation in shallow water environments. Feedback indicating the location of good matches and poor matches will lead the UNC group to re-examine the geologic data and results of statistical analyses. These data and analyses will be examined to determine if there is a variable that is not normally considered an important element in the geologic framework that may be causing mismatches between the geology and acoustics of the margin. The analyses and models will be revised to incorporate the variable, which was previously not included in the geologic data and stochastic model of the margin geology.

PUBLICATIONS

An Estimate of the Bottom Compressional Wave Speed Profiles in the northeastern South China Sea using “Sources of Opportunity”, Y-T Lin, J.F. Lynch, N. Chotiros, C.-F. Chin, A. Newhall, A. Turgut, S. Schock, C.-S. Chiu, **L.R. Bartek**, and C.-S. Liu, IEEE, Journal of Ocean Engineering [submitted and in review]